REMARKS

Claims 1 and 5 are pending in this application. By this Amendment, claim 3 is cancelled without prejudice to or disclaimer of the subject matter contained therein, and claims 1 and 5 are amended to recite features supported in the specification on page 5, lines 21-23, page 12, lines 23-25 and page 15, lines 18-20. No new matter is added by any of these amendments.

Applicants appreciate the courtesies extended to Applicants' representative by Examiner Anderson during the August 12, 2003 interview. In accordance with MPEP §713.04, the points discussed during the interview are incorporated in the remarks below and constitute Applicants' record of the interview.

Reconsideration based on the following remarks is respectfully requested.

I. Request for Acknowledgement that References are Considered of Record

An Information Disclosure Statement with Form PTO-1449 was filed on January 28, 2004. Applicants have not yet received back from the Examiner a copy of the Form PTO-1449 initialed to acknowledge the fact that the Examiner has considered the cited disclosed information.

The Examiner is requested to initial and return to the undersigned a copy of the subject Form PTO-1449. For the convenience of the Examiner, a copy of that form and the PTO date-stamped receipt is attached.

II. Claims 1 and 5 Define Patentable Subject Matter

The Office Action rejects claims 1, 3 and 5 under 35 U.S.C. §103(a) over U.S. Patent 6,284,093 to Ke *et al.* (Ke) in view of *Silicon Processing for the VLSI Era*, v. 1 (pp. 8, 23-27, 32-33, 59, ©1986) by Wolf *et al.* (Wolf), and further in view of U.S. Patent 6,299,982 to Tamatsuka *et al.* (Tamatsuka). This rejection is rendered moot with respect to claim 3 and is otherwise respectfully traversed.

A) Applicants assert that Ke, Wolf and Tamatsuka, alone or in combination, do not teach or suggest a silicon focus ring comprising silicon single crystal used as a focus ring in a plasma apparatus, wherein, in order to produce an intrinsic heavy metal gettering effect of the focus ring, a concentration of interstitial oxygen contained in the silicon focus ring is not less than 5×10^{17} atoms/cm^3 and not more than 1.5×10^{18} atoms/cm^3, and a nitrogen concentration in the silicon focus ring is not less than 5×10^{13} number/cm^3 and not more than 5×10^{15} number/cm^3, the intrinsic gettering effect exceeding a corresponding effect for silicon not doped with interstitial oxygen and nitrogen, and the surface of the silicon focus ring is subjected to etching treatment to remove a mechanical damage layer, as recited in claim 1. Applicants further assert that Ke, Wolf and Tamatsuka fail to teach or suggest a method for producing the same from Czochralski grown single crystal silicon, as similarly recited in claim 5.

Applicants further assert that the main features of the silicon focus ring as recited in the claims include:

(1) a concentration of interstitial oxygen not less than 5×10^{17} atoms/cm^3 and not more than 1.5×10^{18} atoms/cm^3;

(2) a nitrogen concentration not less than 5×10^{13} number/cm^3 and not more than 5×10^{15} number/cm^3; and

(3) the surface of the silicon focus ring is subjected to etching treatment to remove a mechanical damage layer.

B) As described on page 2, line 27 through page 4, line 7 of the specification, even if a focus ring is made of single crystal silicon with high purity as a whole, impurities of heavy metal, are generated from a processing apparatus and the like in a process of forming the silicon focus ring and a plasma etching process and adhere to the surface of the focus ring. The metal impurities not only adhere to the surface of the focus ring, but also diffuse inside

the focus ring, so that defects are generated. These defects resulting from such impurities cause particles to form on a focus ring and lower its useful life.

However, when the silicon focus ring as provided in Applicants' claimed features is used, due to the predetermined interstitial oxygen concentration and the nitrogen concentration, "oxygen precipitation in a bulk portion of the silicon focus ring is promoted sufficiently, and gettering effect can be more effective." See page 5, lines 13-17, page 9, line 14 through page 10, line 9 and page 14, lines 1-9 of the specification. Also, by etching treatment of the surface of the ring, "generation of particles can be reduced, and there are few adhered heavy metal" particles. See page 5, lines 23-24, page 12, line 15 through page 13, line 6 of the specification.

As shown in the examples on pages 14-17 of the specification, silicon wafers were subjected to plasma etching by using each focus ring, and the silicon focus rings for Examples 1 and 2 were doped with oxygen and nitrogen beyond the concentration ranges of claims 1, resulting in increased contamination of the wafers and generation of surface roughness on the silicon focus rings. In contrast, Examples 3 and 4, where the focus rings were doped with oxygen and nitrogen within the concentration ranges of claim 1, were much better than Examples 1 and 2. See Table 1 on page 16 for Examples 1-4. Specifically, as opposed to merely doping the silicon focus ring with nitrogen and the like, only the silicon focus ring, which is controlled to the oxygen and nitrogen concentrations and subjected to etching treatment as recited in claim 1, reduces particle accumulation, thereby reducing surface roughness of the focus ring. See page 17, lines 10-19 of the specification.

C) Regarding the control of oxygen and nitrogen concentrations, by adjusting the rotation of the quartz crucible while the ingot is pulled from the silicon melt, the amount of oxygen, which is molten from the crucible and mixed into the silicon melt, can be controlled to produce the desired concentration of interstitial oxygen in the silicon single crystal. See page

10, line 23 through page 11, line 10 of the specification. Similarly, the nitrogen concentration can be controlled to be in the above-mentioned range by alternatively, placing the silicon wafer having the nitride film in a quartz crucible together with a polycrystalline silicon as the raw material, adding nitride itself in the silicon melt, or using atmospheric gas containing nitrogen. See page 11, line 14 through page 12, line 4 of the specification.

D) Applicants further assert that Ke discloses a protective ring 50 composed of silicon single crystal and describes that "the protective ring 50 preferably is composed of pure silicon. Silicon is advantageous... because it readily can be obtained in forms having extremely low impurity concentrations... Single crystal silicon is preferred because it can be obtained with the highest purity." In particular, Ke teaches protective ring composed of the highest purity silicon single crystal containing no impurities to the extent possible. See col. 6, lines 31-38 and Fig. 3 of Ke.

Unlike Applicants' claimed features, Ke neither teaches nor suggests the problem of impurities of heavy metal adhering to the ring in a process of forming the ring and a plasma etching process. Nor does Ke teach oxygen and nitrogen concentrations of the ring. However, because Ke teaches that a single crystal silicon with highest purity having no impurities is used for the silicon ring as described above, even though oxygen is inevitable when growing a silicon single crystal by the Czochralski method, clearly Ke teaches that impurities such as nitrogen, which is intentionally doped in Applicants' claims, should be avoided in the silicon ring of Ke. Further, there is no possibility to derive from Ke the teaching that the gettering effect can be improved by controlling oxygen and nitrogen concentrations to the specified ranges as in Applicants' claimed features.

E) Wolf describes that "to produce starting material suitable for fabricating semiconductor devices (*i.e.*, wafers)", processes such as slicing, etching, polishing and the like are performed. See page 24, lines 1-2 of Wolf. Also, Wolf identifies requirements for

VLSI are described on Table 2 of page 27 and the last paragraph on page 32. Wolf teaches that "the incorporation of nitrogen in CZ (Czochralski) and FZ (float zone) silicon is being studied as a technique to increase the warpage resistance of wafers. Oxygen is known to increase wafer mechanical strength, and nitrogen appears to play a similar rôle." Moreover, in the first paragraph on page 59, Wolf describes the Czochralski silicon single crystal typically has an oxygen concentration of 5×10^{17} – 1×10^{18} atoms/cm^3 (or 10-20 ppma), and the presence of oxygen in silicon influences bulk oxygen precipitates that provide the basis of intrinsic gettering, wafer warpage resistance, and so on. In particular, Wolf teaches manufacturing processes of wafers for VLSI, and further teaches oxygen and nitrogen in the crystal to prevent warpage of wafers, and that the gettering effect is influenced by oxygen. However, Wolf neither describes nor suggests the silicon focus ring, as provided in Applicants' claimed features.

F) Tamatsuka relates to a silicon single crystal wafer for a device such as a semiconductor integrated circuit. See col. 2, lines 39-51 and claims 11-12 of Tamatsuka. Also, Tamatsuka teaches a silicon wafer with oxygen concentration in the range of 1×10^{18} atoms/cm^3 or less, and nitrogen concentration in the range of 2×10^{14} to 5×10^{15} atoms/cm^3. See col. 2, lines 41-43 of Tamatsuka. Further, Tamatsuka describes that "growth of crystal defects can be sufficiently suppressed when the nitrogen concentration is in the range" described, so that "when the oxygen concentration is low as above, growth of the crystal defects can be further suppressed, and formation of oxide precipitates in the surface layer can be prevented." See col. 2, lines 47-50 of Tamatsuka.

Specifically, Tamatsuka relates to a wafer for VLSI, as does Wolf, and teaches that a silicon wafer with low defects for a device can be obtained by addition of oxygen and nitrogen in specified concentrations. However, Tamatsuka neither teaches nor suggests the silicon focus ring having features recited in Applicants' claims.

G) The Office Action derives selected features from Applicants' claims by applying a silicon single crystal of Wolf with oxygen and nitrogen concentrations of Tamatsuka to a silicon single crystal focus ring of Ke. The Office Action asserts, in the last paragraph of page 5, that the motivation for the combination of Ke, Wolf and Tamatsuka is to lower warpage. This assertion is evidently hindsight of the present specification, and even one of ordinary skill in the art cannot derive the silicon focus ring of Applicants' claims with improved gettering effect from the combination of these applied references.

H) As aforementioned, Ke teaches that a single crystal silicon with highest purity containing no impurities is used for a silicon focus ring. At least, Ke clearly teaches that impurities such as nitrogen should be avoided. In contrast, Applicants' claimed features purposely introduce nitrogen into the silicon focus ring. Thus, Ke teaches away from Applicants' claimed features.

I) As described above, the Office Action asserts that the motivation for combining the applied references is to reduce warpage. If there is even slight warpage on a silicon wafer, it becomes extremely difficult or impossible to fabricate a minute and precise integrated circuit on a surface thereof. Therefore, it is essential to prevent warpage of the silicon wafer. However, unlike a silicon wafer, a silicon focus ring does not include fabrication of such minute and precise integrated circuits thereon. Thus, warpage prevention is not required to the same level for the focus ring as for the wafer. Any motivation to reduce warpage fails to apply to one of ordinary skill in the art for producing a focus ring. There is no description in any of the applied references regarding warpage of a focus ring reduced to levels appropriate a wafer, even in the present specification.

Therefore, it is completely unreasonable to lower warpage for a focus ring to a level applicable to a wafer. Given that Ke specifically prefers having no impurities in a focus ring, while Wolf and Tamatsuka contain oxygen and nitrogen impurities in a wafer for warpage

reduction, etc., there is no motivation for one of ordinary skill in the art to combine these teachings, as the reasons for Wolf and Tamatsuka do not apply to Ke.

J) None of the applied references teaches or suggests the problem of impurities of heavy metal having adhered to the ring in the processes of forming the ring and plasma etching using the ring. Therefore, the applied references fail to teach or suggest that impurities of heavy metal adhering to the surface of the ring are eliminated by etching treatment on its surface, and the improved gettering effect, as provided in Applicants' claims.

Thus, the combination of the applied references to achieve Applicants' claimed features of oxygen and nitrogen concentrations can only be achieved by hindsight reasoning. Further, the contamination of heavy metal having adhered to the ring during forming and plasma etching can be effectively eliminated by etching treatment, and extremely high gettering ability, is further recited in Applicants' claimed features.

A *prima facie* case of obviousness for a §103 rejection requires satisfaction of three basic criteria: there must be some suggestion or motivation either in the references or knowledge generally available to modify the references or combine reference teachings, a reasonable expectation of success, and the references must teach or suggest all the claim limitations. See MPEP §706.02(j). Applicants respectfully assert that the Office Action has not satisfied this burden with Ke, Wolf and Tamatsuka in rendering Applicants' claims unpatentable.

K) For at least these reasons, Applicants respectfully assert that the independent claims are now patentable over the applied references. Consequently, both pending claims are in condition for allowance. Thus, Applicants respectfully request that the rejection under 35 U.S.C. §103 be withdrawn.

III. Conclusion

In view of the foregoing amendments and remarks, Applicants respectfully submit that this application is in condition for allowance. Favorable reconsideration and prompt allowance are earnestly solicited.

Should the Examiner believe that anything further is desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned representative at the telephone number listed below.

Respectfully submitted,

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WPB:GWT/gwt

Attachments:
Petition for Extension of Time
Copy of earlier filed PTO-1449

Date: March 26, 2004

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